Transforming the Grid to Revolutionize Electric Power in North America

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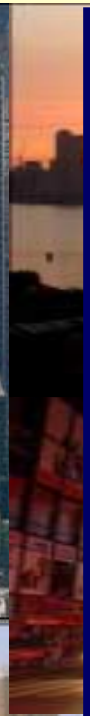
Blackout - August 14, 2003



By-The-Numbers

1 Canadian Province

3 deaths

8 U.S. states

12 airports closed

23 cases of looting in Ottawa

250+ power plants

9,266 square miles

61,800 MW of power lost

1.5 million Cleveland residents without water

50 million people

$4.5-12 billion in economic activity lost

Reliability Events

June 3
Over 400,000 without power in Texas

May 31
Power outages causes fire at hospital, school in Illinois

May 27
Schools closed by power outage in Detroit, Michigan

May 17
Multiple power outages affect Michigan-Indiana Border

May 12
Tree limbs cut off power to 31k in Utah

January 14
12,000 lose power in Minnesota

*Outages are still widespread, frequent, and costly to the economy**

April 29
200k lose power in Washington State

January 28
70,000 lose power in Baltimore, Maryland

February 6
Over 2,500 lose power in Ohio; reasons not known

March 1
15,000 homes and businesses lose power in Florida

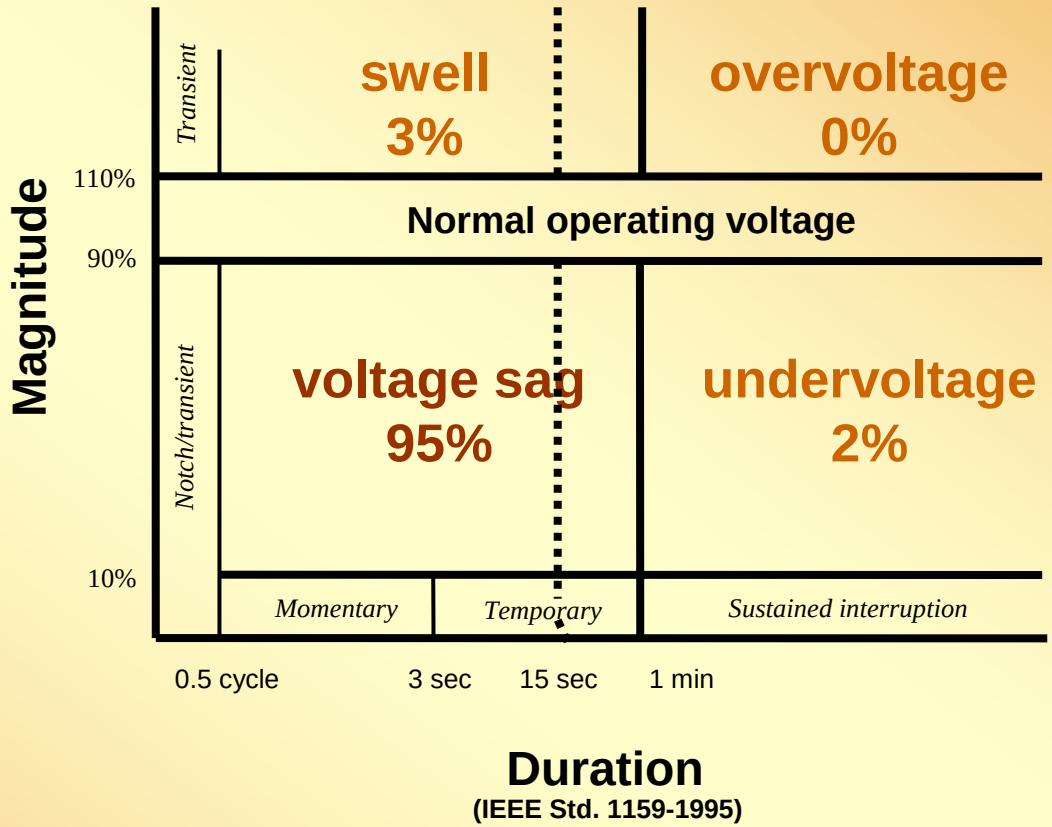
March 12
20,000 lose power in Albuquerque, New Mexico

April 22
Bird causes 3rd power failure in 10 days at LAX in California

*Recent LBNL study estimates annual costs from outages at $80 Billion

Power Quality Events

- **Power quality refers to subtle deviations in the quality of delivered electricity that causes customer's equipment to fail or mis-operate**
- **<u>98% of fatal power quality events last less than 15 seconds</u>**
- **But outages lasting a few cycles can cause hours of downtime**
- **Costing U.S. industry $80 billion annually**
  - **$53 B: Momentary**
  - **$27 B: Sustained**



Leadership from all Levels

"…it's clear that the power grid needs an overhaul. It needs to be modernized. As we go into an exciting new period of American history, we want the most modern electricity grid for our people… we need more investment; we need research and development…"

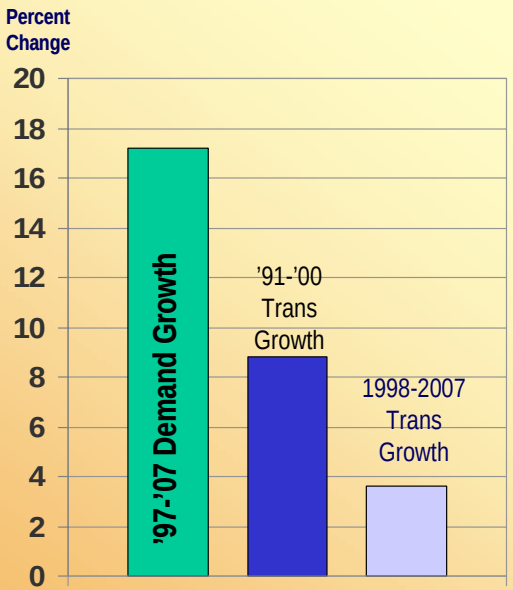
President George W. Bush, September 2003

"When the lights go out, modern life as we know it grinds to a sudden halt. Transportation is interrupted, communications fail, water systems shut down, factory work is disrupted, food spoils, businesses lose money, and people are inconvenienced and even endangered. "

Secretary of Energy Spencer Abraham, September 3, 2003

Rationale for Federal Leadership

Under-Investment in T&D



Source: NERC

No Forcing Function for Change

- Industry fragmented, leaderless
- Financial risks and uncertainties
- States - "Patchwork quilt"
- Siting and permitting logjams
- Utility RD&D spending in decline

Public Interest at Risk

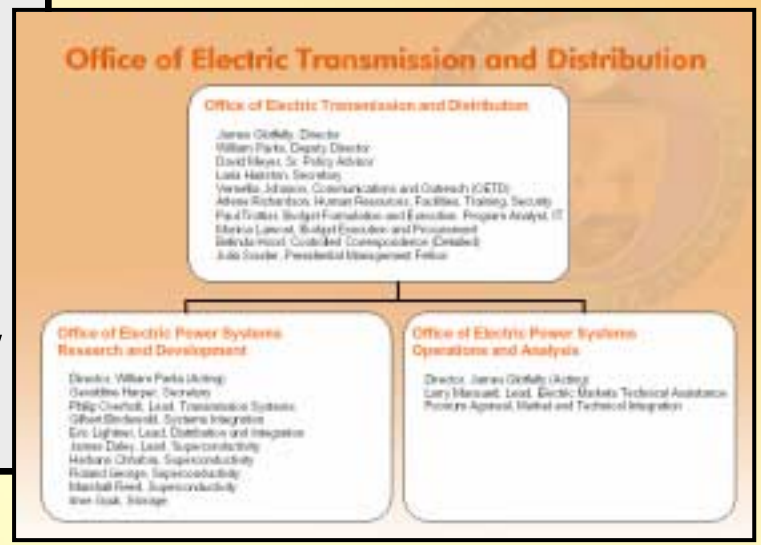
- Economic growth and jobs creation
- Consumer electricity bills
- Public health and safety
- Environmental protection
- Energy security and reliability

When will the "tipping point" be reached when industry investment triggers itself and includes new technologies and approaches?

Office of Electric Transmission and Distribution

Mission

To lead a national effort to help *modernize and expand America's electric delivery system* to ensure a more reliable and robust electricity supply, as well as economic and national security

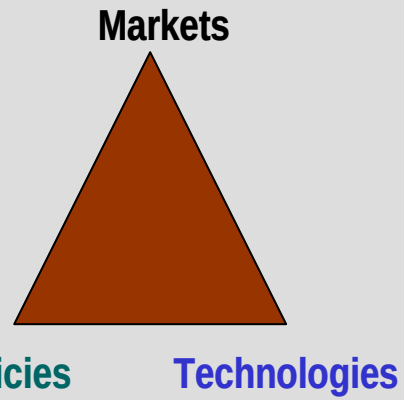







OETD's Role within DOE

Integrated Approach



Transmission & Distribution Technology RD&D

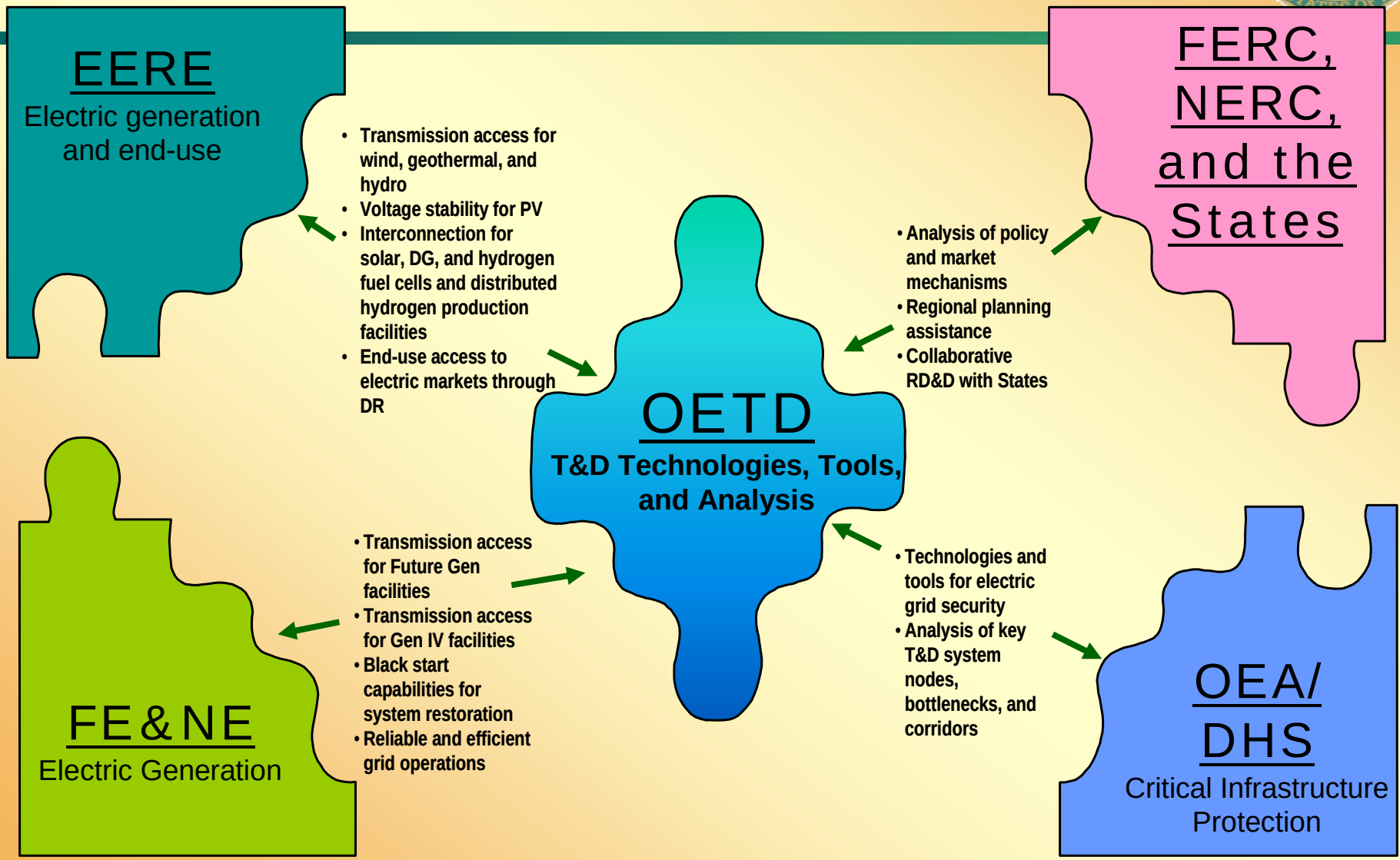
Policy analysis, modeling, and regional planning tools; coordination of Federal electricity issues

Electricity restructuring assistance to regions and states

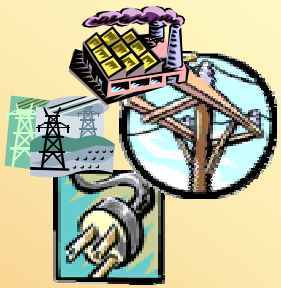
Energy Strategic Goal

To protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy

Interdependencies & Crosscutting Initiatives



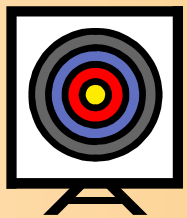
National Electric Vision and Technology Roadmap



Industry Today

Vision

Technologies
Markets
Policies



Goals

Roadmap

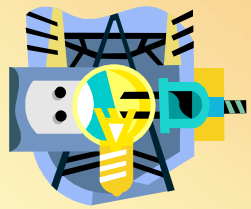
Action Agenda

Priorities

Implementation

RD&D
Tech Transfer
Electric Markets

Partnerships



Industry Tomorrow

Workshop-April 2003

Workshop-July 2003

August 2003

Budget Request and Multi-Year Plan

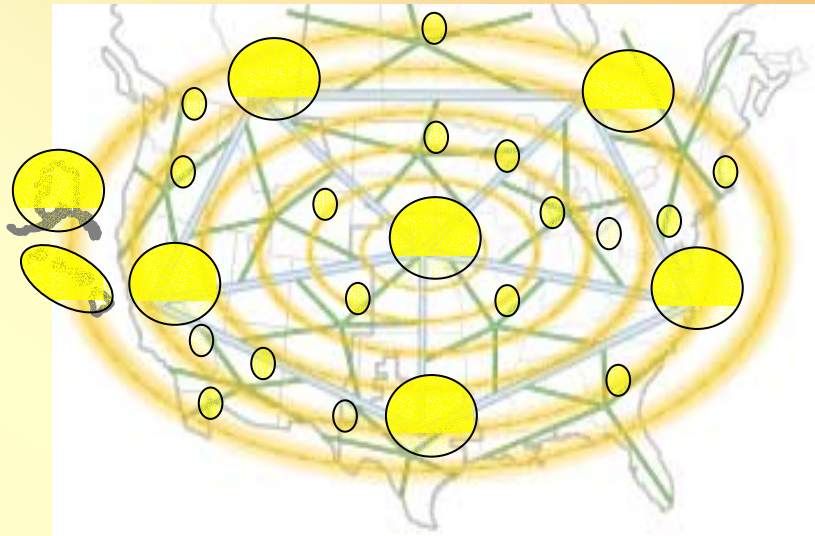
Fall 2003

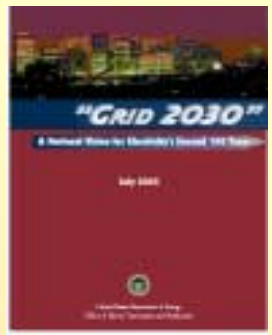
"Grid 2030" – A National Vision

Imagine the Possibilities…

- Electricity is ultra-reliable and affordable
- A self-correcting power grid, resilient to terrorist sabotage
- A national energy superhighway
- Consumer participation in a more reliable system
- Near-zero economic losses from power outages and power quality disturbances

"Grid 2030"





Vision
July 2003

Roadmap
Jan 2004

Why "Grid 2030"

- Complete system approach
- Enables more renewables, clean-coal, and nuclear
- Helps realize hydrogen infrastructure
- Enables modernized conservation – DR & DG
- Industry committed

Present value of national benefits could exceed $96 billion

Source: "Estimating the Benefits of the GridWise Initiative" Rand 2004
(Includes deferred capital and O&M costs, lower reserve margins, reduced outage and power qaulity costs, and savings from efficiency improvements.)

- **Local, Micro- and Mini-Grids**
  - Ultra-reliability and power quality
  - Real-time pricing
  - Lower outage and PQ costs
  - Self-contained system
- **Regional Interconnections**
  - Increased volume of transactions
  - Quicker detection and restoration
  - Lower outage and PQ costs
- **National Electric Backbone**
  - Enables more renewables-RPS alternative
  - Enables clean-coal to sell nationally
  - Competitive national markets with ultra-reliability and lower losses

Electric Delivery Technologies Roadmap

Action Agenda **for Turning the Vision into Reality**

Design "Grid 2030" Architecture

Conceptual framework that guides development of the electric system from transmission to end-use

Develop Critical Technologies

Advanced conductors, electric storage, high-temperature superconductors, distributed intelligence/smart controls, and power electronics that become building blocks for "Grid 2030"

Accelerate Technology Acceptance

Field testing and demonstrations that move the advanced technologies from the laboratory and into the "tool kit" of transmission and distribution system planners and operators

Strengthen Market Operations

Assessing markets, planning, and operations; improving siting and permitting; and addressing regulatory barriers bring greater certainty and lower financial risks to electric transactions and investment

Build Partnerships

Leveraging stakeholder involvement through multi-year, public-private partnerships; working with States to address shared concerns

OETD's Approach to Success

Mandates

Technology Challenges

- Unobtrusive Power Lines
- Lower Cost Storage
- Power Electronics
- Clean Power Generation
- Long Distance HTS
- Real-time Information Systems
- Advanced Composite Conductors

Partnerships

Roadmap for Designing "Grid 2030" Architecture

	2010	2020	2030
Local Distribution	Phase 1 Design & Testing	Phase 2 Technology Development & Market Acceptance	Phase 3 Manufacturing & Scale-up
Regional Interconnection			
National Backbone			

Annual Targets

DOE General Goal 4: Energy Security

OETD Program Goal: Modernization

Critical Objectives

1. Reliability
   Reduce/Eliminate Blackouts
2. Efficiency
   Reduce Energy Losses
3. Affordability
   Reduce Cost of Delivered Electricity

National Reliability Challenges

- ***Prevention*** – keep problems from occurring
- ***Detection*** – ready for immediate action
- ***Response*** – proper ”tool kits” for any contingency
- ***Modernization*** – “next generation” of grid technologies

Prevention

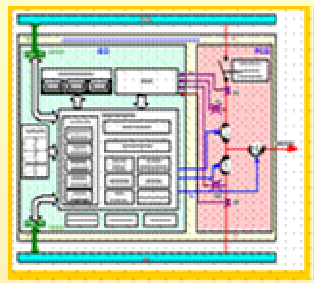
Stop reliability problems from occurring in the first place

Technologies for Today

- Advanced conductors and tower designs
- Modeling and system planning tools
- Communications
- Training

Composite Core Conductors

Communications Systems



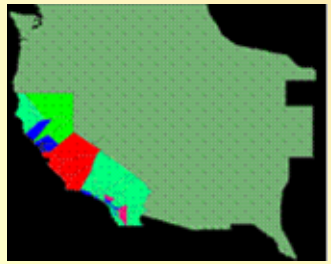
Modeling and Simulation Packages

Training Seminars

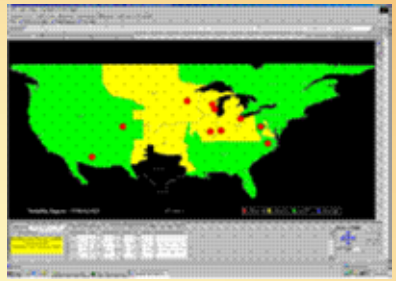
Detection

Improve grid operator readiness for taking action immediately

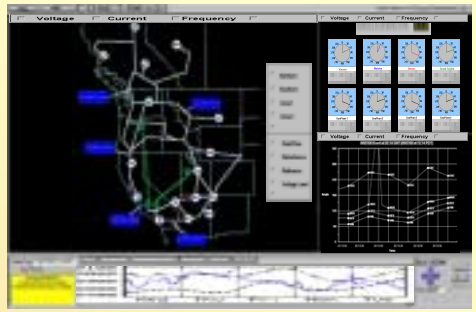
- **Monitoring Systems**
  - Frequencies
  - Voltages
  - VARs
  - Phasors
  - Line Sag
- **Data Acquisition**
- **Visualization Tools**
- **Communications**
- **Training**



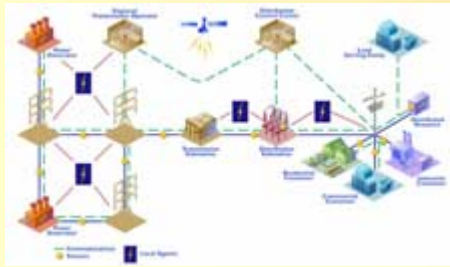
Voltage and VAR Monitoring



ACE Frequency Monitoring



Synchronized Phasor Applications



Distributed Sensing and Controls Systems

Response

Equip operators with a portfolio of resources comprising the best available tools and techniques

Technologies for Today

- **Distributed Generation**
- **Energy Storage Systems**
- **Demand Response**
- **Communications**

Industrial Gas Turbines

Aggregated Water Pumping Loads

Zinc-Bromine Battery System

Smart Thermostat

Reciprocating Engine Gen Sets

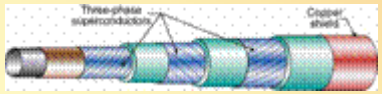
Microturbines

Modernization

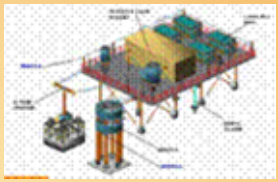
"Next generation" technologies for meeting future needs

Technologies for Tomorrow

- "GridWorks" Technologies
  - High temperature superconducting devices
  - Cables
  - Transformers
  - Fault current limiters
- "GridWise" Technologies
  - Distributed intelligence
  - Distributed energy
  - Distributed communications and controls
- Advanced Materials
- Power Electronics

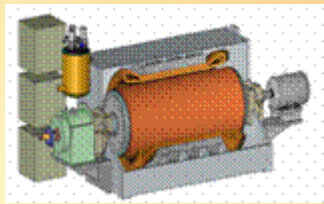


Superconducting Cable

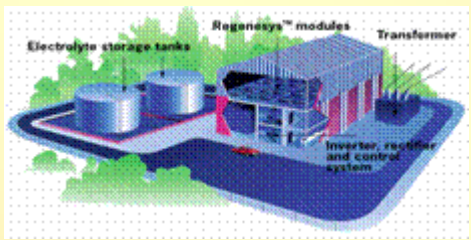


Fault current limiter

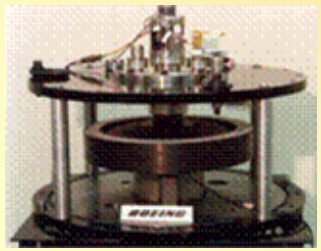
Superconducting Transformer



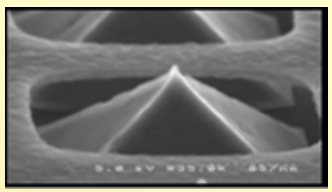
SuperVAR System



Advanced Energy Storage



Superconducting Flywheel



Diamond Devices